ANSWERS: Identifying organic substances

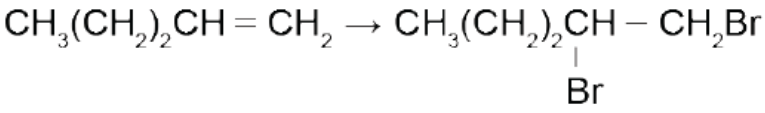
1. Three liquids will be identified and the fourth will be the 'last one'. The tests used to identify the liquids include:
$Cr_2O_7^{2-}$ / H^+ which will turn from orange to green when the ethanol is oxidised to ethanoic acid.
Ethanoic acid can be identified by an acid-base reaction with sodium carbonate. Bubbles of gas will be produced. Sodium ethanoate / ethanoate ion is formed.
Hex-2-ene can be identified by an addition reaction with bromine water, which turns from red / brown to colourless straightaway when added to the alkene. It will form 2,3-dibromohexane
Hexan-1-amine will be the chemical left over that will not react with any of the given reagents.

2. Water
Add water to the five liquids. Two solutions will dissolve in water (ethanol, ethanamine), three will not (pentan-1-ol, pent-1-ene and pentane).

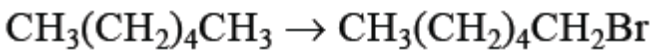
Litmus
Use the solutions formed by dissolving in water. Add red litmus paper to both solutions.
One will not change the colour of the litmus paper; this is ethanol. One will turn red litmus blue; this is ethanamine.

Bromine water
Test the liquids that did not dissolve in water by reacting fresh samples with bromine water. Pent-1-ene will (rapidly) turn the orange solution to colourless. (UV) light is required for the reaction with pentane / Br_2 does not react with pentane / no colour change / slow colour change. The remaining liquid is pentan-1-ol.
(Accept that pentane and pentan-1-ol cannot be separated by this method if this is outlined).

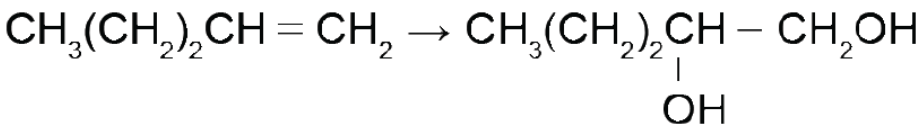
3. Either of the two reagents could be used. Br_2 will react with both substances, but the reaction with hexane is slow and requires UV light. Permanganate will only react with pent-1-ene. Br_2 reacts with pent-1-ene in an addition reaction. Br_2 changes colour from orange to colourless.
Reaction is:



Br_2 reacts with hexane in a substitution reaction, UV light is required for the reaction / Br_2 does not react with hexane. Br_2 changes colour from orange to colourless / no colour change.
Reaction is:



MnO_4^- / H^+ will react only with pent-1-ene.
The reaction is an oxidation / addition reaction. Acidified MnO_4^- changes from purple to colourless. (MnO_4^- changes colour from purple to brown).
Reaction for permanganate is:



4. Butanamine (aminobutane) is basic, so will turn red litmus paper blue. Butanoic acid is acidic, so will turn blue litmus paper red.

5. Water

Add water to the five solutions. Three solutions will dissolve in water (ethanol, aminoethane, ethanoic acid), two will not (hexane, hex-1-ene).

Litmus

Use the solutions formed by dissolving in water. Add both red and blue litmus paper to the solutions in water.

One will not change the colour of the litmus paper, this is ethanol.
One will turn blue litmus red, this is ethanoic acid.
One will turn red litmus blue, this is aminoethane.

Test the solutions which did not dissolve in water by reacting fresh solutions with bromine water. If the solution turns from brown to colourless the solution is hex-1-ene.
Hexane will not react with the bromine water.

Equations with water:

$CH_3COOH + H_2O \rightarrow CH_3COO^- + H_3O^+$

$CH_3CH_2NH_2 + H_2O \rightarrow CH_3CH_2NH_3^+ + OH^-$

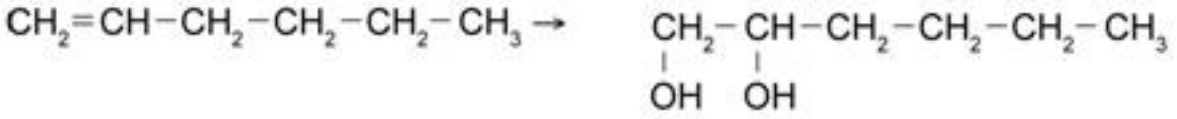
Equation with bromine water:

$CH_3– CH_2– CH_2– CH_2– CH=CH_2 + Br_2 \rightarrow CH_3– CH_2– CH_2– CH_2– CHBr– CH_2Br$

6. Add Na_2CO_3 to a sample of each organic substance. The substance which produces bubbles is the propanoic acid. The bubbles are CO_2.

$2CH_3CH_2COOH + Na_2CO_3 \rightarrow 2CH_3CH_2COONa + CO_2 + H_2O$

Add MnO_4^-/H^+ to the two remaining samples. One of the two samples will turn the solution from purple to colourless. This is hex-1-ene.



The organic substance that does not change the colour of acidified potassium permanganate nor reacts with sodium carbonate is hexane.

7. Orange solutions are acidified dichromate and bromine water.

Add one of the orange substances to all three colourless substances.

If the orange substance decolourised, then it was bromine water. The solution it decolourised was hex-1-ene.

If the orange substance turned green, it was acidified potassium dichromate. The solution that made the acidified dichromate turn green was methanol. The substance that did not react with either orange reagent was hexane.

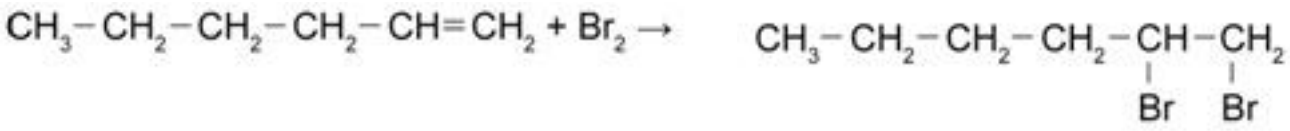
$CH_3OH \rightarrow HCOOH$

$CH_2CH(CH_2)_3CH_3 + Br_2 \rightarrow CH_2BrCHBr(CH_2)_3CH_3$

(Or accept miscibility argument for methanol versus hexane / hex-1-ene.)

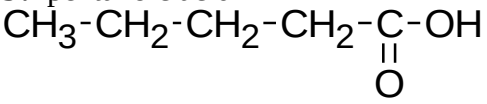
	Methanol	Hexane	Hex-1-ene
Br_2	No Reaction	No Reaction	Decolourises
$Cr_2O_7^{2-}$ / H^+	Turns from orange to green	No Reaction	No Reaction

8. Hexene will react with a dilute solution of bromine water. This will change from orange to colourless. 1, 2-dibromohexane will be formed. Hexene will not react with Zn.

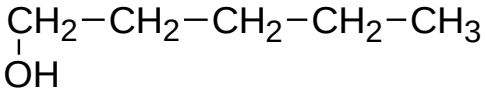


Ethanoic acid will react with Zn and fizzing / bubbles will be observed.
Ethanoic acid will not react with a dilute solution of bromine water.
$2CH_3COOH + Zn \rightarrow (CH_3COO)_2Zn + H_2$

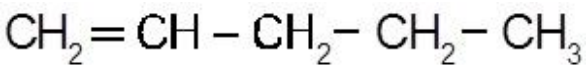
9. pentanoic acid

 **OR** $CH_3CH_2CH_2CH_2COOH$

pentan–1–ol

 **OR** $CH_2OHCH_2CH_2CH_2CH_3$

pent–1–ene

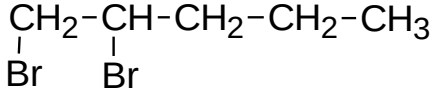


Full structures showing all C–H bonds may be used.

BROMINE FIRST

1. Add bromine solution to a sample of each of the 3 liquids:

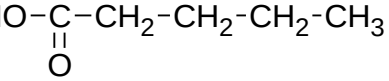
orange colour goes colourless → pent–1–ene

as  (OR 1,2–dibromopentane) is formed.

Orange colour remains → pentan–1–ol or pentanoic acid.

2. Then add permanganate solution to separate samples of the remaining 2 liquids (pentan-1-ol, and pentanoic acid):

purple colour changes to a brown precipitate, indicating pentan–1–ol

as  (OR pentanoic acid) is formed from the alcohol.

If purple colour remains, then the liquid is pentanoic acid.

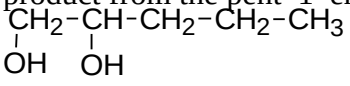
OR

PERMANGANATE FIRST

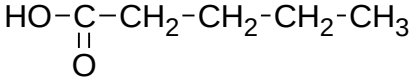
1. Add potassium permanganate solution. If the purple colour remains, (no reaction) the liquid is pentanoic acid.

Permanganate reacts with both pent–1–ene and pentan–1–ol:
purple solution changes to a brown precipitate.

The product from the pent–1–ene is pentan 1,2 diol

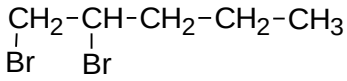


while the product from the alcohol is pentanoic acid



2. Test these two remaining liquids with bromine. Bromine reacts with pent–1–ene but not with the alcohol.

orange colour goes colourless with pent–1–ene

as  (OR 1,2–dibromopentane) is formed.

10. a) (i) Acidified potassium dichromate.
(ii) Propan–1–ol will turn $Cr_2O_7^{2-}$ from orange to green.
Remains orange with propanoic acid.
OR
(i) Acidified potassium permanganate.
(ii) Propan–1–ol will turn MnO_4^- from purple to colourless.
Remains purple with propanoic acid.
OR
Other suitable test and related observations. eg wet blue litmus/ aqueous CO_3^{2-}/Mg.

b) Hex−1−ene will react immediately with Br_2 and the Br_2 will change from orange to colourless. Hexane will react slowly in the presence of UV light and the orange Br_2 will gradually fade, eventually becoming colourless. Hex−1−ene is unsaturated due to the C=C and undergoes an addition reaction, forming 1,2–dibromohexane.

$CH_2CHCH_2CH_2CH_2CH_3 + Br_2 \rightarrow CH_2BrCHBrCH_2CH_2CH_2CH_3$

Hexane is saturated as all C−C bonds are single and undergoes a substitution reaction forming a bromohexane (eg 1−bromohexane) and HBr.

eg $CH_3CH_2CH_2CH_2CH_2CH_3 + Br_2 \rightarrow CH_2BrCH\ CH_2CH_2CH_2CH_3 + HBr$

11. In (i) Other suitable tests may exist. (But not flame test or $KmnO_4$ or water solubility
In (ii) must mention observation, for the same test, for both chemicals. If there's a colour change, candidate must mention both colours

Note: but-2-ene BP = 4°C butan-1-ol BP = 118°C
(i) Add bromine water to a sample of each.
(ii) Butan−1−ol: Orange colour of bromine remains , But−2−ene: Orange colour of bromine disappears /goes colourless OR bromine decolorises
(iii) An addition reaction occurs OR occurs due to C = C / unsaturated bond : (in alkene)
OR
(i) Add $Cr_2O_7^{2-}$ / H^+.
(ii) Butanol: orange colour of $Cr_2O_7^{2-}$ goes green
But-2-ene: orange colour of $Cr_2O_7^{2-}$ remains
(iii) The (primary) alcohol can be oxidised with acidified dichromate /alkene cannot be oxidised by acid dichromate.
OR (i) Observe state
(ii) Butan-1-ol is a liquid
Butene is a gas
(iii) Butan-1-ol has stronger attractive forces between molecules or equivalent statement.

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